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AUTHOR Cardinale, Loretta A.
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ABSTRACT

This study explored the enhancement of comprehension of expository text by three specific types of embedded explication--etymological, causal, and analogical--together with momentum effects from sequencing. Four factors were examined: (1) the experimental effects of presenting the section of the script containing explications of new terms before the new concepts; (2) the effects of etymological explications on acquisition of the meaning of new terms; (3) the effects of explication of causal relations on construction and retrieval of information; and (4) the effects of analogical explication on integration of information in long-term memory. Instructional materials were developed which presented new vocabulary before new facts or new facts before new vocabulary. For each sequence, one control group received filler material and three groups received different types of explication. Subjects were 184 undergraduate students enrolled in elementary science education courses, and the instructional content consisted of a an 1,800 word instructional unit on the human heart. On the first day of the study, students were given 15 minutes to read the scripts. Two days later they received the test packet, which included a 5-minute drawing test. Overall, the effects of explication were significant on the drawing and terminology tests, while the effects of vocabulary sequence were significant only on the drawing test. It is concluded that, in order to be effective, text-based explication must target mental processes, and that, in cases where the information is conceptually dense, embedded explication can both relieve density and enhance processing. (4 tables, 29 references) (BBM)

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Author:

Loretta A. Cardinale

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THE FACILITATION OF VOCABULARY ACQUISITION BY EMBEDDING EXPLICATION IN EXPOSITORY TEXT

The ability to read and understand text is vital for learning and remembering information. Learners typically have more difficulty reading expository than narrative text (Spiro & Taylor, 1980). A lack of motivation and interest may result in less time spent on reading and thus less experience with reading expository as well as narrative text (R. Anderson, Wilson, & Fielding, 1988).

Informative text that facilitates understanding, learning, and remembering uses certain text characteristics that facilitate learning from written materials. Standard characteristics of expository text include structure, coherence, unity, and audience appropriateness (Armbruster & T. Anderson, 1984). However, even texts that include those characteristics may lack features that enhance comprehension. Explication of information by familiar examples, causal relations, vocabulary usage, or analogy should enhance comprehension (Singer & Donlan, 1989). Specific types of explication may affect aspects of information processing differently. Those effects must be determined.

Information Processing and Learning from Expository Text

Mayer proposed four components of the encoding process: selection, acquisition, construction, and integration (Mayer, 1988; Mayer & Greeno, 1972; Weinstein & Mayer, 1986). It is each of these components that this study addressed by embedding specific types of explication: etymological, causal, and analogical.

Explication of Information

To explicate means to state directly, instead of requiring the reader to infer, organize, or construct relationships (Singer & Donlan, 1989). Learning will occur if the text directly explains the terminology or causal relations (Bean, Singer, Sorter, & Frazee, 1987). Thus, explication of information should be a concern for instructional designers.

Explication by Etymology in Text

Word etymologies are concerned with the origins and derivations of a word. Medical terminology is derived from about 4,000 Greek and Latin terms that form various prefixes, suffixes, and roots (Pepper, 1949). Familiarity with those Greek and Latin terms and an understanding of their use would save a student from memorizing more than 50,000 words and facilitate selective attention and acquisition.

Explication of Causal Relations in Text

Causality is an action that regularly produces an effect, and it means that there is a predictable or functional relationship between a cause and its effect (Schlick, 1949). Explicating causal relations should link one new term with another as it is encountered in the text. This linkage would organize the information and thus affect recall of simple arrangements and relationships (Mayer, 1988; Mayer & Bromage, 1980). Thus, in terms of Mayer and Greeno's (1972) model, explicating causal relations should enhance constructive processes. Retrieval processes may be enhanced as a result of linkages among knowledge from the text.

Explication by Analogy

The essence of analogical thinking is the transfer of knowledge from one situation to another by finding correspondence between the aspects of two different bodies of information (Gick & Holyoak, 1983). Where prior knowledge exists, an analogy can bridge the gap between the familiar and the unfamiliar by providing anchors for assimilation. Explication by analogy should enhance integration of new information with prior knowledge in long-term memory. This should improve both encoding and retrieval processes.

Momentum Effects from Sequencing

In most expository text, the author defines new terms before new factual information is presented. This is consistent with the role of prerequisite information in learning (R. Gagne, Briggs, & Wager, 1985). However, determining the effects of embedded explication requires a set of learning conditions that will favor the use of passages containing explications by the reader. There would be a point at which expository text is so easy that readers don't rely upon embedded explication or so difficult that readers will not attempt to learn the information. The arrangement of these experimental conditions must take momentum effects into account. Research investigating momentum effects has been associated with changes in the difficulty of instructional material that result from varied sequences (Rothkopf & Coatney, 1974).

Purpose

The purposes of this study were: 1) to examine experimental effects of presenting the section of the script containing explications of new terms before the new concepts (Vocabulary-First Sequenced Script) versus presenting that section after the new concepts (Vocabulary-Last Sequenced Script); 2) to examine the effects of etymological explications on acquisition of the meanings of new terms; 3) to examine the effects of explication of causal relations on construction and retrieval of information, and; 4) to examine the effects of analogical explication on integration of information in long-term memory.

Methods

To test the hypotheses, instructional materials were developed which presented new vocabulary before new facts (Vocabulary-First Sequenced Script) or presented new facts before new vocabulary (Vocabulary-Last Sequenced Script). For each sequence, one control group received filler material, and three groups received different types of explication resulting in a 2 (vocabulary sequence) X 4 (embedded explication) factorial design.

Subjects

A total of 184 undergraduate students at the Pennsylvania State University who were enrolled in elementary science education classes received 5 attendance points toward their final course grade for completing the materials and delayed test. All students completed a test delayed by 2 days. The eight treatments were randomly distributed among the students in each group.

Materials

The instructional content developed by Dwyer (1965) consisted of

an 1,800 word instructional unit describing the parts of the human heart, the internal functions of those parts and the interrelated functioning of the heart. With the addition of explication passages written by the investigator, the instructional unit was expanded to 2,100 words.

Embedded Passages

Four types of embedded passages were included in the original text and were all located within the section discussing new terminology: The Heart and its Functions. This section was presented first to half of the subjects and last to the remaining half. Each embedded passage consisted of approximately the same number of words and was located at precisely the same point in the parallel texts. All explications referred to the same terms. The filler material, historical in nature, did not refer to the functions or parts of the heart.

Filler Material. Twelve passages consisting of historical material was added to the control group scripts in order to provide equivalent reading material with the same number of words. This filler material discussed the study of heart transplantation through the development of the artificial heart. For example:

> For the past twenty years or so doctors and surgeons have been studying the techniques of the transplanting of the human heart.

Explications. Each script contained one set of twelve explication passages that were etymological, causal, or analogical. They were placed at precisely the same points in all scripts. The Vocabulary-First Sequenced Script presented the section containing explicated vocabulary first while Vocabulary-Last Sequenced Script presented that section last.

Explication by Etymology. Etymological explications discussed the same terms as other explications. Information regarding the naming of the part of the heart or the meaning of prefixes and suffixes was stated within approximately the same number of words as the fillers and other explications. For example, the following explication discusses the meaning of prefixes and suffixes in pericardium:

> The word, PERICARDIUM can be broken down into two parts: PERI- and -CARDIUM. The root, CARDIUM comes from the Latin word for HEART while PERI comes from a Greek term meaning "around the outside".

Explicated Causal Relations. Explication of causal relations were approximately the same word count as the filler material and the other embedded passages. For example, the following statement links the function and characteristics of the pericardium to the term covered next in the script, the epicardium:

> The pericardium must be tough enough to protect the heart yet flexible enough to expand and contract. If it were damaged in some way, the epicardium would become shredded.

These statements were designed to show relationships between the names and functions of the parts of the heart. In this case, the

epicardium is linked to the pericardium as it is in the heart.

Analogical Explication. The analogies were literal whenever possible, that is, they discussed both description and function. For example, both the appearance and function of the pericardium is included in this analogy:

> Plastic wrap for food, Saran Wrap or Handiwrap, is tough, transparent and elastic. It protects food. In a way, the pericardium is like plastic wrap.

The analogies were designed to activate prior, familiar knowledge and link it to the new terminology. The investigator attempted to generate meaningful, relevant analogies for the targeted subjects. Charts summarizing the script formats are found in Tables 1 and 2.

Delayed Test

A delayed test without an immediate test provides useful information about the use of embedded explication. The use of analogies has been shown to have effect on long-term memory (Gick & Holyoak, 1980; Simons, 1984). This supports the use of a delayed test without immediate testing. In addition, the interest of this study was to determine the amount of information held in long-term memory and not short-term memory. Immediate testing would tend to identify the amount of information insufficiently encoded to be stable in long-term memory (Ausubel, 1968). The goal of this study was not to determine the amount of information lost from short-term memory, but rather the information that had a degree of stability in long-term memory (i.e. after a delay period). The eighty-item test was structured into the following sections and given in the following order: Drawing, Identification, Terminology, and Comprehension. The types of questions in each of the four tests addressed a different aspect of the heart material. The Drawing Test required the student to draw a simple line picture of the heart and place the corresponding number of the 20 identified parts listed on the test. This tested the skill level of labeling or naming (R. Gagne et al., 1988). The Identification Test required a naming or labeling skill by recognition rather than cued recall. Without visual aids present during the reading, however, students had to infer the locations of structures from the information provided in the reading material. The Terminology Test, at the factual level, required the student to recognize the correct part of the heart, as an answer, for the function or description written in the question. The Comprehension Test, at the conceptual level, presented two functional and eighteen sequential questions that required the student to recall and apply information from different portions of the reading material. This test required knowledge of both the parts and functions of the heart along with information about circulation and the cycle of the heartbeat. The Kuder-Richardson 20 reliability coefficients are in Table 1.

Procedure

On the first day of the study, students were given 15 minutes to read the scripts. Two days after reading, students received the test packet. The drawing test was given for 5 minutes and the other three parts of the test were given for 10 minutes each. The four tests were given in the same order to minimize possible interference effects between tests. Students were instructed not to go back to the previous

test.

Results

Overall, the effects of explication were significant on the drawing and terminology test. The effects of vocabulary sequence were only significant in the drawing test. The means and variances are in Table 2.

Cued Recall of Labels on the Drawing Test

On the drawing test, a list of 20 terms was provided to the student producing a cued-recall test condition. All terms were discussed in the script. The findings of the ANOVA of the group achievement on the drawing test resulted in significant differences among the treatment groups for both vocabulary sequence and embedded explication. There was no interaction between main effects. The summary of the ANOVA is in Table 3. From multiple comparisons, analogical-explication and causal-explication group means from the drawing test were significantly higher than the control group means.

Recognition of Labels on the Identification Test

The findings of the analysis of treatment group achievement on the identification test resulted in no significant difference among the score variances. Since subjects received no line drawings during the reading, this confirms the need for visual representation during instruction.

Recognition of Facts on the Terminology Test

The findings of the ANOVA of the group achievement on the terminology test resulted in significant differences among the treatment groups for explication. There was no interaction between main effects. The summary of the ANOVA is in Table 4. From the multiple comparison of the means, the groups receiving analogical explications and causal explications scored significantly higher than the control groups.

Recognition of Concepts on the Comprehension Test

Questions about the function and structure of the heart tested students at the conceptual level. The multiple choice test presented a high level of difficulty to students. In this study, reading material only once may have proved to be inadequate. The findings of the analysis of treatment group achievement on the comprehension test resulted in no significant difference among the score variances.

Discussion

The purpose of this study was to examine the effects of implicitly embedding short passages explicating new vocabulary on the acquisition of verbal information. Since the original text was conceptually dense and presented at least 12 new terms in 700 words, embedding explicative passages increased the ease of reading and enhance retrieval. Filler material had no effect other than to equilibrate reading time and momentum effects.

Overall, the treatment groups performed better on the measure of cued recall of labels, the drawing test, than the control groups that received filler material. The group mean scores for subjects receiving analogies and causal statements were significantly higher than the

filler group mean scores on this test. Reading analogies and causal statements enhanced retrieval processes (Britton et al., 1989). These results indicate that richer propositions were encoded (J. Anderson & Reder, 1979).

The etymology groups did not score significantly higher than the control groups on any measures. This may be due to the subjects' lack of familiarity with etymologies (Richek, 1988). Training would have been required (Weinstein et al., 1988). The measure of cued recall depended upon retrieval processes. The etymologies may have induced students to attend and acquire the terms, but retrieval, which was measured, was not enhanced.

On the measure of cued recall, the students receiving the Vocabulary-Last Sequenced Script performed significantly better than the students receiving the Vocabulary-First Sequenced Script. This suggests that students who read the facts and concepts before the vocabulary relied on the embedded explications. This is consistent with Rothkopf's (1988) conclusions about momentum effects.

On the measure of factual verbal information, the terminology test, the groups receiving analogies scored significantly higher than all other groups. This supports the findings of other studies that examined analogical reasoning and indicates that analogies provide an opportunity for the learner to integrate new information with information held in long-term memory (Bean et al., 1985; Gentner, 1988; Gentner & Gentner, 1983; Gick & Holyoak, 1983; Hayes & Tierney, 1982; Simons, 1984; Vosniadou & Schlomm, 1988). The consistent performance of the groups receiving analogies on measures of cued recall and measures of recognition supports other research reporting the enhancement of both encoding and retrieval processes (Britton et al., 1989; E. Gagne, Yarbrough, Weidman & Bell, 1984).

Students reading the Causal Explication/Vocabulary-Last Sequenced Script treatment performed significantly better than students reading the etymologies on the measure of cued recall that tested naming. This supports the findings of previous studies that examined the effects of explicating causal relations (Bean et al., 1987; Herman et al., 1987; Pedersen et al., 1988). However, the Causal/Vocabulary-First students did not score significantly higher than the etymology groups. This supports Rothkopf's (1988) theory of momentum effects. The groups receiving the Causal Explication/Vocabulary-First Sequenced Script may have attended less to the explications while the groups receovomg the Causal Explication/Vocabulary-Last Sequenced Script may have attended to the explications and relied more on those reading aids.

Conclusions

The results of this study may be considered for the design of text-based instruction. To be effective, text-based explication must target mental processes. When construction is required by a task, then causal explications would benefit the learner by facilitating linkage between vocabulary. For example, learning the terminology for parts of a machine where each component causes an action and reaction would be facilitated by causal explication. Analogical explication would enhance the integration of new information with prior knowledge in situations where the vocabulary is unfamiliar, complex and abstract such as those found in microcomputer education. Particularly in cases where the information is conceptually dense, embedded explication can

both relieve density and enhance processing (Singer & Donlan, 1989). The type of explication depends upon the goal of instruction, the method of testing, and the familiarity of the information (E. Gagne et al., 1984).

The results of this study suggest that training is necessary for the use of etymologies for vocabulary acquisition. Students must fully understand the structure of words, in particular, the role of prefixes, suffixes, and roots. They must also have some schema for foreign languages. A familiarity with classical languages may enhance vocabulary acquisition. This is an area for further research.

Recommendations for Future Research

Future research about learning from text requires specific measurement techniques that target specific aspects of information processing. Each of the treatments in this study could be replicated by modifying the tests, content, subjects, and conceptual density in order to determine specific processes that occur while learning.

Another area for future research would be to study the effect of training students to use implicitly embedded learning strategies. Biology instruction, with its extensive use of language, would be a valid area to attempt training in the use of etymologies. Perhaps if training could demonstrate the efficiency and application of knowing a few thousand prefixes and suffixes instead of tens of thousands of difficult terms, results would be significant.

Table 1. Kuder-Richardson Test Reliability Coefficients

Test	K-R 20	Item Type
Drawing Test (n = 20)	0.83	Cued Recall
Identification Test (n = 20)	0.81	Forced Choice
Terminology Test (n = 20)	0.83	Forced Choice
Comprehension Test (n = 20)	0.77	Forced Choice
Total-Criterion (n = 80)	0.92	Combination of above items

Table 2. Means and Variances of the Delayed Criterion Tests

Vocabulary-First Sequenced Script

	Treatment Group			
	Filler	Etymology	Causal	Analogy
Test				
Labels: Cued Recall				
Mean	3.00	3.52	4.61	4.70
Variance	6.00	7.62	9.18	4.93
Labels: Recognition				
Mean	7.09	7.70	7.65	8.74
Variance	12.96	6.60	14.59	7.02
Facts: Recognition				
Mean	7.43	7.65	8.35	9.04
Variance	5.43	12.67	10.43	14.14
Concepts: Recognition				
Mean	7.09	7.17	7.78	7.04
Variance	8.18	9.86	9.80	13.10

Vocabulary-Last Sequenced Script

	Treatment Group			
	Filler	Etymology	Causal	Analogy
Test				
Labels: Cued Recall				
Mean	3.78	4.13	5.48	5.56
Variance	7.45	9.92	6.97	5.43
Labels: Recognition				
Mean	7.34	8.39	8.39	8.78
Variance	6.76	12.53	3.80	14.74
Facts: Recognition				
Mean	7.30	8.43	8.78	9.43
Variance	8.47	8.88	9.73	15.44
Concepts: Recognition				
Mean	6.83	8.39	8.56	7.83
Variance	10.24	15.44	9.18	7.78

Table 3. ANOVA Summary Table for the Effects of Sequence and Explication on the Drawing Test.

Source	df	SS	F	
Sequence Group	1	29.96	4.03*	
Explication Group	3	106.10	4.92**	
Sequence by Explication Interaction	3	0.36	0.02	
Error	176	1266.00		
Total	183	1401.43		

* Significant in terms of the 0.05 level

** Significant in terms of the 0.01 level

Table 4. ANOVA Summary Table for the Effects of Sequence and Explication on the Terminology Test.

Source	df	SS	F
Sequence Group	1	6.3	0.59
Explication Group	3	86.7	2.70*
Sequence by Explication Interaction	3	4.9	0.15
Error	176	1875.1	
Total	183	1973.0	

* Significant in terms of the 0.05 level

** Significant in terms of the 0.01 level

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